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Reduced representational momentum for subtle dynamic facial expressions in individuals with autism spectrum disorders

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ABSTRACT

The cognitive mechanisms underlying social communication via emotional facial expressions are crucial for understanding the social impairments experienced by people with autism spectrum disorders (ASD). A recent study (Yoshikawa & Sato, 2008) found that typically developing individuals perceived the last image from a dynamic facial expression to be more emotionally exaggerated than a static facial expression; this perceptual difference is termed representational momentum (RM) for dynamic facial expressions. RM for dynamic facial expressions might be useful for detecting emotion in another's face and for predicting behavior changes. We examined RM for dynamic facial expressions using facial expression stimuli at three levels of emotional intensity (subtle, medium, and extreme) in people with ASD. We predicted that individuals with ASD would show reduced RM for dynamic facial expressions. Eleven individuals with ASD (three with Asperger's disorder and eight with pervasive developmental disorder not otherwise specified) and 11 IQ-, age- and gender-matched typically developing controls participated in this study. Participants were asked to select an image that matched the final image from dynamic and static facial expressions. Our results revealed that subjectively perceived images were more exaggerated for the dynamic than for the static presentation under all levels of intensity and in both groups. The ASD group, however, perceived a reduced degree of exaggeration for dynamic facial expressions under the subtle intensity condition. As facial expressions are often displayed subtly in daily communications, reduced RM for subtle dynamic facial expressions may prevent individuals with ASD from appropriately interacting with other people as a consequence of their difficulty detecting others' emotions.

1. Introduction

Individuals with autism spectrum disorders (ASD) have difficulty with social interaction, including communication via emotional facial expressions (American Psychiatric Association [APA], 2000). Clinical observation studies have consistently confirmed that individuals with ASD are impaired in many types of social interactions involving facial expressions. For example, previous studies examining children's behavior under structured conditions have demonstrated that individuals

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with ASD exhibit reduced attention (Sigman, Kasari, Kwon, & Yirmiya, 1992), emotional behaviors (Corona, Dissanayake, Arbelle, Wellington, & Sigman, 1998), and facial reactions (Yirmiya, Kasari, Sigman, & Mundy, 1989) in response to the facial expressions of other individuals.

Extensive work has also been done to investigate the processing of emotional facial expressions in individuals with ASD, though findings still remain rather inconsistent. Almost all of these studies have used static facial expressions as stimuli. In some of these studies, individuals with ASD have shown more perturbation in the ability to recognize facial expressions than typically developing individuals (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Braverman, Fein, Lucci, & Waterhouse, 1989; Celani, Battacchi, & Arcidiacono, 1999). However, other studies have failed to show such impaired recognition (Adolphs, Sears, & Piven, 2001; Castelli, 2005; Grossman, Klin, Carter, & Volkmar, 2000).

Everyday communication of emotions is largely based on dynamic facial cues. Real-life facial expressions reflect dynamic, moment-to-moment changes in emotional state (Ekman & Friesen, 1975). A growing body of studies has consistently shown that various psychological activities including subjective perception (Yoshikawa & Sato, 2008), recognition (Ambadar, Schooler, & Cohn, 2005; Bould & Morris, 2008; Bould, Morris, & Wink, 2008), and emotional responses (Sato & Yoshikawa, 2007a, 2007b) are enhanced in response to dynamic expressions as compared with static facial expressions. Neuroimaging studies have also demonstrated that some brain regions show increased activity in response to dynamic, rather than static, facial expressions (LaBar, Crupain, Voyvodic, & McCarthy 2003; Sato, Kochiyama, Yoshikawa, Naito, & Matsumura, 2004). Taken together, these findings indicate that dynamic facial expressions are more effective for emotional communication than are static facial stimuli. These findings also suggest the possibility that individuals with ASD may have more difficulty processing dynamic facial expressions than static facial expressions.

To investigate the processing of dynamic facial expressions in individuals with ASD, pioneering studies have examined their recognition of these stimuli (Gepner, Deruelle, & Grynfeltt, 2001; Tardif, Lainé, Rodriguez, & Gepner, 2007). Gepner et al. (2001) showed that a strobe presentation (i.e., presentation of a few frames of a clip revealing changes in dynamic facial expressions, to produce the illusion of motion) improved facial expression recognition as measured by a matching-to-sample task, compared to static presentation, in typically developing controls but not in individuals with ASD. However, individuals with ASD were able to recognize both dynamic and static facial expressions. Using a similar matching-to-sample method, Tardif et al. (2007) demonstrated that individuals with ASD were less able than typically developing individuals to recognize dynamic and static facial expressions, but slowing down the presentation of dynamic facial expressions improved their recognition. These studies suggest differences in performance between individuals with ASD and typically developing individuals in the recognition of dynamic facial expression. However, dynamic presentation did not improve the recognition of facial expressions by typically developing individuals in these studies. Recently, Kessels, Spee, and Hendriks (2010) found that labeling of dynamic facial expressions, specifically those of fearful and disgusted emotions, was defective in individuals with ASD. However, recognition involved several processing stages; these included perceptual processing, interpretation of emotional meaning, and selection of an appropriate verbal label. Consequently, it is difficult to reach definite conclusions about which of the stages involved in processing dynamic facial expressions are impaired in individuals with ASD. To elucidate impairments specific to ASD, it is necessary to use an experimental paradigm in which dynamic presentation enhances the processing of facial expressions in typically developing individuals and to examine each component of this dynamic facial expression processing, such as the perception and interpretation of emotional meaning.

Functional magnetic resonance imaging (fMRI) studies have shown that dynamic facial expressions elicit atypical neural activation in several brain regions of ASD individuals (Pelphrey, Morris, McCarthy, & Labar, 2007; Sato, Toichi, Uono, & Kochiyama, 2012). Pelphrey et al. (2007) presented dynamic and static facial expressions depicting anger, fear, or neutral emotions, and found that observation of dynamic facial expressions elicited less activation in the superior temporal sulcus/middle temporal gyrus (STS/MTG), fusiform gyrus (FG), amygdala (AMY), and medial prefrontal cortex (MPFC) in individuals with ASD compared to typically developing individuals. Sato et al. (2012) extended these findings using happy and fearful emotional stimuli. The results showed that, compared to the typically developing group, the ASD group exhibited less activation in the brain regions described above, and also in the inferior frontal gyrus (IFG), in response to dynamic facial expressions. These regions are involved in various aspects of processing of social stimuli, including visual analysis of the dynamic aspects of faces (STS/MTG; Allison, Puce, & McCarthy, 2000); visual analysis of the invariant aspects of faces; the subjective perception of faces (FG; Haxby, Hoffman, & Gobbini, 2000); emotional processing (AMY; Calder, Lawrence, & Young, 2001); attribution of mental states (MPFC; Frith & Frith, 2003); and motor mimicry (IFG; Iacoboni, 2005). It is tempting to speculate that deficits in such psychological functions influence the processing of dynamic facial expressions in individuals with ASD. However, as fMRI has inherent technical limitations in terms of temporal resolution, and as the abovementioned brain regions are functionally and structurally connected, it remains unclear which level or levels of processing are impaired in the processing of dynamic facial expressions in individuals with ASD.

To investigate the more rapid components of dynamic facial expression processing, Uono, Sato, and Toichi (2010) recently studied the subjective perception of facial expressions in individuals with ASD. This study measured the representational momentum (RM) of dynamic facial expressions. RM refers to a phenomenon in which the perceived final position of a moving object shifts in the direction of the actually observed movement (Freyd & Finke, 1984; Hubbard, 1990). This effect has also been reported in the perception of biological stimuli, including dynamic facial expressions (Hudson, Liu, & Jellema, 2009; Yoshikawa & Sato, 2008). Uono et al. presented dynamic or static facial expressions and asked participants to choose from a display of variable emotional expressions the image that matched the final image from the presented expression. In this task, dynamic presentation clearly enhanced processing of facial expressions in typically developing individuals